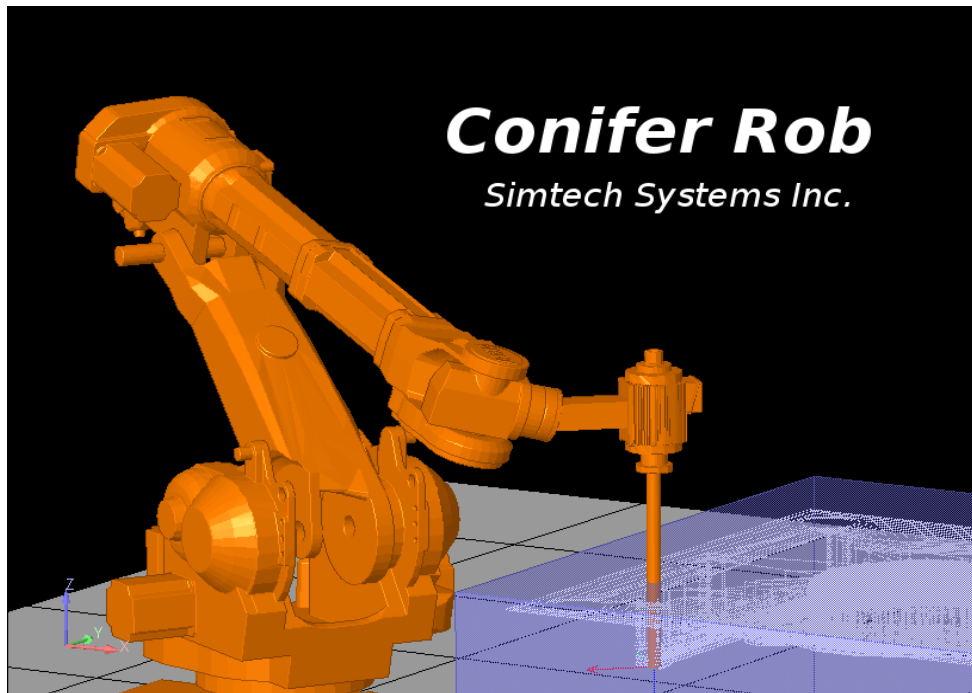# User Manual

Industrial Robot Simulation Software

Version 1.4.0 for Windows XP and Windows Vista

Simtech Systems Inc.

Version 2008-07-23

CONTENTS

1. INTRODUCTION

Overview

Conifer Rob is a precision tool that fills the process gap between machining path generation system (such as a CAD system) and the industrial robot running the machining program. With the help of Conifer Rob one can quickly and safely convert and move the machining program in *.apt format into the robot for execution.

With the help of Conifer Rob the positioning of the workpiece can be easily designed. Reachability analysis allows identifying problems in the positioning and ensuring that selected positioning a functioning one. Conifer Rob converts the imported machining path into a robot program and optimizes the program for optimum accuracy and reachability. Conifer Rob also supports doing manual corrections to the machining path. Finally, the animation and collision detection features in Conifer Rob support checking the robot program for safety before pushing the robot program into execution.

Conifer Rob can help you in:
– Converting machining path into a robot program
– Optimizing robot robot program
– Designing the positioning of the workpiece in the robot cell
– Ensuring safety of the generated robot program
– Correcting problems in generated robot program

Installation and Licensing

<u>New Installation</u>

Prerequisites

To successfully install Conifer Rob you need:

1) PC with at least 512MB of RAM and 10GB of free disk space. 1GB of RAM and 30GB of free disk space is recommended.

2) Windows XP 32bit or Windows Vista (32bit or 64bit)

3) Display driver with some hardware 3D acceleration (most display adapters these days have)

4) Conifer Rob Installer executable

5) Valid ethernet address (MAC) bound license file for Conifer Rob or alternatively a USB hardware dongle for Conifer Rob. With dongle based licenses you need to have the USB hardware dongle driver installer aswell.

Running Installer

Run the Conifer Rob installer executable.

1) On Windows Vista you will be prompted to wether you will allow the unidentified software to modify your system. To proceed you must click **Allow**

2) License Agreement view will open. You have to select **I Agree** to go forward with the installation.

3) You will then have the option of selecting the default robot model and language for the Conifer Rob installation. Select robot model and language from the list and click **Next.**
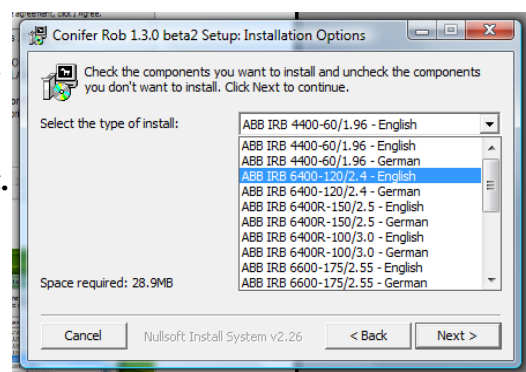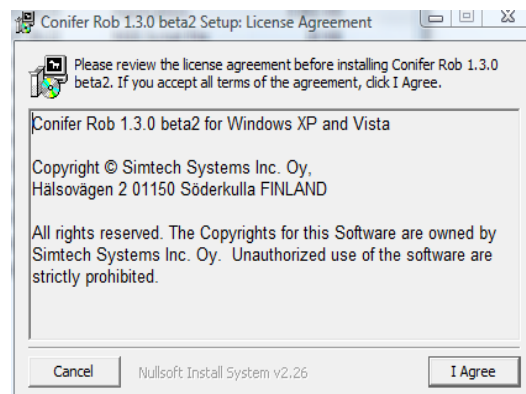
4) Next you are prompted for the installation directory for Conifer Rob. It is recommended to keep the default "C:\Program Files\Conifer Rob". Click **Install.**
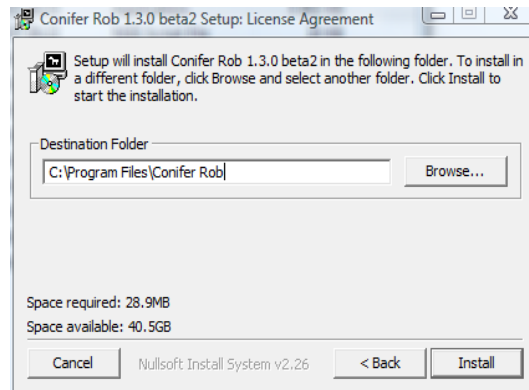
5) Installer will now install some more files and this takes some time.

6) Finally the installation will complete and you will be prompted to close the installer. Click **Close.**
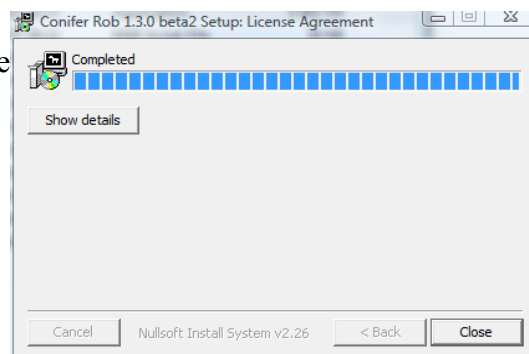
   Now - a shortcut to Conifer Rob has appeared on your desktop (and also in Start menu).

Evaluation Period

If a license file or dongle is not installed the Conifer Rob will run in evaluation version mode for the period of one week after installation. After the evaluation period the Conifer Rob will require either a license file or dongle to be installed.

Installing License File

If you have an ethernet address (MAC) bound license file (coniferlic.txt) you should copy it in the directory where you installed the Conifer Rob. The default installation directory is "c:\program files\conifer rob"

Installing Dongle Driver

If you have been provided with hardware key (dongle) based license you will have to install the dongle drivers. You do this by running the hardware dongle driver installer from Alladin. The installer executable in named 'hdd32.exe'.
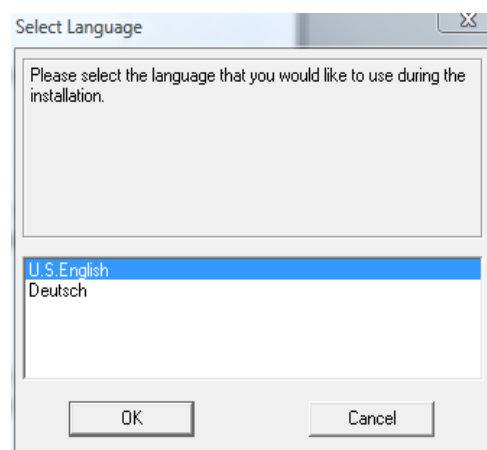
1) The driver installer will as your for the installation language. Select language and click 'OK'

2) From the Wellcome dialog click 'Next'

3) From the End User License Agreement dialog you have to select 'I agree' and click 'Install'
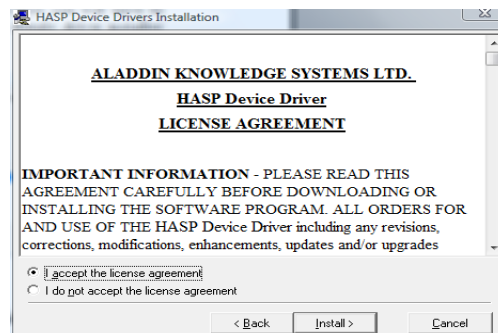
4) Driver will not install. This may take few minutes

5) Finally, you are greeted with dialog stating that driver has been successfully installed. Click 'Finnish' here to end the installation.

Configuring FTP access

If the PC that is running Conifer Rob software has TCP/IP network access directly to the robot that will be running the generated robot programs, you can configure Ftp access properties to the Conifer Rob and thus allow the software to communicate directly with the robot via FTP.

The parameters reside in configuration file **coniferrob.ini** which is located in the same directory where the Conifer Rob executable is, by default this is "C:/program files/Conifer Rob" or "C:/program files (x86)/Conifer Rob".

The file has entries

```
robotftphost=
robotftpusername=
robotftppassword=
robotftpposedirectory=
robotftpprogramdirectory=
```

If you fill in to these the robot's host name or IP address, and the username and password of the robot's ftp service, the directory in the robot where the robot keeps position (*.pos) files and the program directory in the robot (where robot programs are stored), the Conifer Rob can access & update these directly in the robot via FTP.

64 bit installations

Conifer Rob is a 32bit Windows application but it runs on 64 bit windows systems aswell.

2. User interface

Toolbars

<u>Top Toolbar</u>

New simulation project. Same as 'New' from the File menu.

Open simulation project document. Same as 'Open' from the File menu.

Save simulation project document. Same as 'Save' from the File menu.

Print. Same as Print from the File menu. Prints the current window.

About. Same as About in the Help menu. Displays About dialog that contains copyright information and the Conifer Rob executable version.

Zoom In.

Zoom Out

Move view to left

Move view to right

Move view to downwards

Move view to upwards

Rotate view

Rotate view

Rotate view

Rotate view

Rotate view

Rotate view

Reset view to default location

View along Y axis

View along X axis

View along Z axis

Orthographic perspective

Use realistic perspective

Show gemetries in wireframe mode

Show geometries in filled polygon mode

Show geometries in shaded polygon mode

Show / hide selected geometries

Toggle transparency on selected geometries

Righthand Toolbar

Default mouse selection mode

Mouse zoom mode. Left mouse button dragging zooms the view in/out.

Mouse moves viewport. Left mouse button dragging moves the view.

Mouse rotation. Left mouse button dragging rotates the view. Left mouse
button drag with CTRL key pressed down will move the viewport. Mouse
wheel button drag zooms the view in/out.

Rotating path stage with mouse. After APT source has been loaded in the system you can run the robot to a stage in a path, select mouse rotation mode by pressing this button and then rotate the path stage with left mouse button on the screeen and while holding the button down dragging mouse from left horizontally.

Point selection/measurement mode. Clicking on geometry will tell the coordinate location of the point in which user clicked.

Mouse selection mode: Replace selection. In this mode the new selection replaces the old selection. However, if SHIFT key is pressed during selection the new selection is added to the current selection instead of replacing it.

Mouse selection mode: Add to selection. In this mode the new selection is added to the old selection.

Mouse selection mode: Remove from selection. In this mode the new selection is removed from the old selection. However, if SHIFT key is pressed during selection the new selection is added to the existing selection.

Stages Toolbar

Move robot to previous stage in current path

Move robot to next stage in current path

Stop animation

Run path as an animation. Visualization will show robot performing the path stages.

Open stages dialog. The stage dialog shows the current path as a list of stages and allows detailed observation and manual manipulation of the path stages.

Animation Speed Toolbar

While running robot program as animation the animation speed can be changed from this toolbar by either dragging the slider or entering speed (100% = real time) manually in the text box.

Menus

<u>File</u>

New	Create new simulation project. The simulation project will be initialized using default settings for robot selection, robot home position, tool container and tool selection.
Open	Open an existing simulation project.
Save	Save currently open simulation project.
Save As..	Save currently open simulation project with different name.
Print	Prints the current window.
Print Preview	Print preview.
Print Setup...	Setup printer and print settings for Print operation
Export STLs	Export currently selected geomeries as STL files
Export APT	Export currently loaded path as APT source
Run Batch	Run a batch job described in a separate text file. This operation allows you to create batch sets that optimize several *.apt files and generate robot programs and the main program in a single run.
Upload Program to Robot	Uploads recently generated robot programs to the robot via FTP
Export Original APT	Exports the *.APT program as it was loaded into Conifer Rob, with all the changes made in Conifer Rob reverted.
Supervisor Mode...	Enter supervisor mode.

<u>View</u>

Toolbar	Hide/show top toolbar
Selection Bar	Hide/show left side toolbar
Status Bar	Hide/show status bar at the bottom of the screen
Doublebuffering	Enable/disable doublebuffering in 3D visualization.
Zoom	Zoom in/out the view
Move	Pan the view
Rotation	Rotate the view
Projection	Select orthographic/perspective projection for the view
View Mode	Select 3D rendering mode, either wireframe, hidden surface or

	polygon
Clipping	Setup clipping box for the view. Using clipping allows looking inside geometries.
Hilight Sharp Edges	Enable/disable edge hilight feature in 3D drawing. Edge hilight draws sharp edges in the geometry with hilighted color which makes it easier to quickly see the geometric features in drawing.
Sharp Edges Treshold...	Setting edge treshold for hilight sharp edges feature.
Hide all / Show all	Toggles geometry visibility for all geometries in the view
Hide object(s) / Show object(s)	Toggles geometry visibility for the selected geometries.
Show floor	Toggles floor visibility
Coordinate System Arrows	Toggles coordinate system arrows visibility
Show Path Normals	Toggles path normal (i.e. tool orientation) visibility
Capture Picture	Save the currently viewed screen as either a JPG or PNG picture file.
Save as AVI File...	Visualize the robot running the current path in an AVI video file.
Surface Color..	Change surface color of currently selected geometries
Background Color...	Change background color for the view.

Model

Information	Generic information about current simulation project
Load APT File...	Load APT path in the current simulation project.
Set Robot Velocity...	Set robot velocity settings
Path Positioning...	Position path in workpiece coordinate system
Robot Positioning...	Positions robot in the robot cell.
Workpiece Positioning...	Positions the workpiece in the robot cell.

Check for Collisions	Checks the currently loaded path for collisions.
Add STL...	Add an obstacle geometry to the robot cell
Remove STL...	Remove an obstacle geometry from the robot cell
Position STL...	Position an obstacle geometry within the robot cell
Position Floor...	Change floor level in Z direction
Manage Tool Containers...	Manage tool container library
Manage Tools...	Manage tool library
Select Tool Containers...	Select current tool containers for the robot.
Select Tool...	Select current work tool for the robot.

Help

Help Topics...	Browse help file
About Conifer Rob...	Version and licensing information about Conifer Rob.

Supervisor State

Some of the operations require supervisor authentication before they become available. User can enter supervisor state by selecting 'Supervisor Mode..' from the 'File' menu. A supervisor login dialog will appear asking for the current supervisor password. The same dialog can also be used for changing the supervisor password. The default supervisor password is 'silirimpsis'.
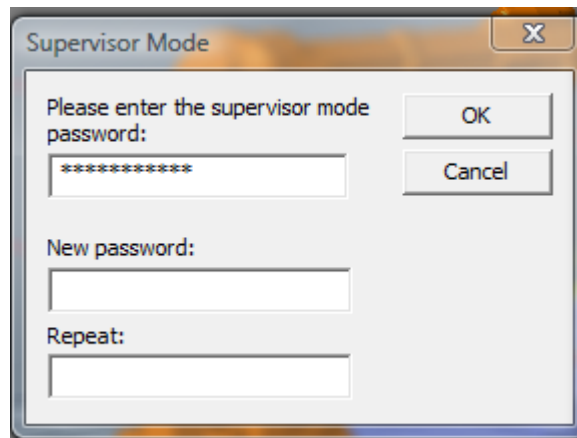
Should you ever loose the supervisor password contact the Conifer Rob support for instructions on how to reset the password.

3. Visualization

Moving, Zooming and Rotating The View

The view to the robot cell can be panned, zoomed and rotated by several means.
The dropdown menu 'View' contains 'Zoom', 'Move' and 'Rotate' submenus for this purpse.

Also the toolbar at the top of the main screen contains buttons for navigating the view.

Finally selecting move or rotate modes from the toolbar on the right side of the screen allows navigating the view with mouse.

Selecting Objects

Geometric objects can be selected by clicking them with mouse. The selected geometries are drawn with white color. There object selection works differently depending on which selection mode is selected. There are three different selection modes can be selected from the left side toolbar.

The default mode replace the current selection with the new one. However, if SHIF key is pressed down during mouse click the object is added to the selection instead.

Mouse selection mode: Add to selection. In this mode the new selection is added to the old selection.

Mouse selection mode: Remove from selection. In this mode the new selection is removed from the old selection. However, if SHIFT key is pressed during selection the new selection is added to the existing selection.

Clipping Planes

Clipping planes can be set dropdown menu
View->Clipping...

A dialog will open from which clipping planes along main axis can be defined. Setting clipping
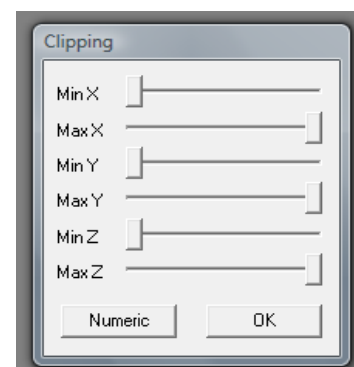
planes allows looking inside geometric objects as the surfaces that lie outside the clipping box are not drawn.

Floor

Setting Floor Level

This option allows changing the floor level Z coordinate. By default the floor level is at Z=0.

This operation requires supervisor login.
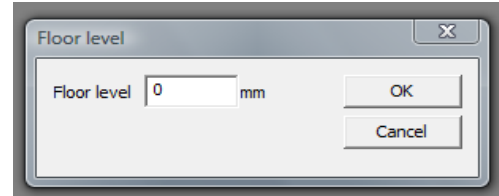
Hiding Floor

Hiding floor in visualization can be helpful if the floor level is blocking the view to objects that are positioned below the floor level. Floor visibility can be toggled from dropdown menu **View->Show Foor.**

Coordinate Systems

Global Coordinate System

Global coordinate system arrows are shown on the left side of the main screen. The global coordinate system arrows are always on and unlike other coordinate system arrows they are **not** drawn in the coordinate system origo.

Robot Coordinate System

Robot coordinate system arrows are enabled from **View->Coordinate System Arrows->Show Robot Coordinate System Arrows**. When enabled coordinate system arrows are drawn in the robot local coordinate system origo.
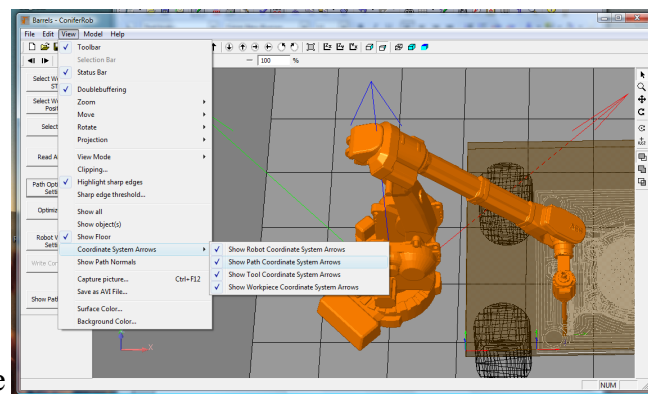
Workpiece Coordinate System

Workpiece coordinate system arrows are enabled from **View->Coordinate System Arrows->Show Workpiece Coordinate System Arrows**. When enabled coordinate system arrows are drawn in the workpiece local coordinate system origo.

This option is not available when workpiece has not been defined

Path Coordinate System

Path coordinate system arrows are enabled from **View->Coordinate System Arrows->Show Path Coordinate System Arrows**. When enabled coordinate system arrows are drawn in the path local coordinate system origo.

This option is not available when APT source has not been loaded.

<u>Tool Coordinate System</u>

Tool coordinate system arrows are enabled from **View->Coordinate System Arrows->Show Tool Coordinate System Arrows**. When enabled coordinate system arrows are drawn in the tool local coordinate system origo.

This option is not available when tool has not been selected.

Path Normals

Showing path normals is enabled from **View->Show Path Normals** menu. When enabled the path visualization will draw a path normal for each path stage point indicating the tool orientation at that location.

This option is not available when APT source has not been loaded.
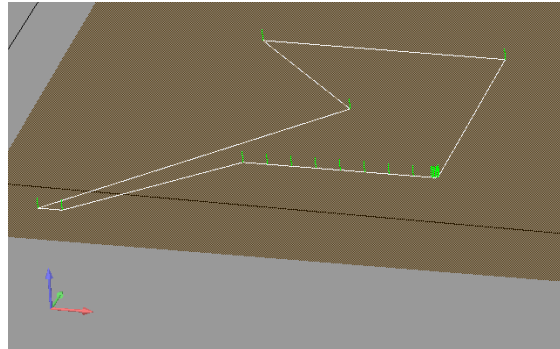
Hiding and Showing Objects

With this option it is possible to hide STL geometries and thus see other geometries that may be hidden within them. First select the option by clicking on the STL geometry with mouse and then use this function to hide the geometry. Selection mode buttons at the right side of the window can be used for selecting multiple STL geometries when necessary. When some STLs are hidden this menu entry is renamed as **Show object(s) / Show All** and selecting this will render the selected objects visible again.

Tweaking Colors

Surface colors for geometries in the robot cell (the robot parts, workpiece, tool containers, tool and obstacles) can be modified by selecting the geometry with mouse (it will be drawn white to show that it is selected) and then selecting dropdown menu **View->Surface Color..**

A color picking dialog will appear from which new color can be selected for the geometry.

Background color for the screen can be modified from dropdown menu **View->Background Color..**
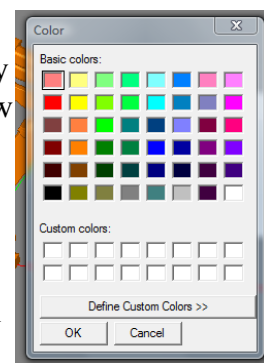
Wireframe / Flat / Shaded Visualization

Geometry visualization mode can be changed by selecting the geometry and then clicking the appropriate visualization mode icon in top toolbar.

Wireframe mode shows the geometry triangulation with no filling color.

User Manual: Conifer Rob 1.4
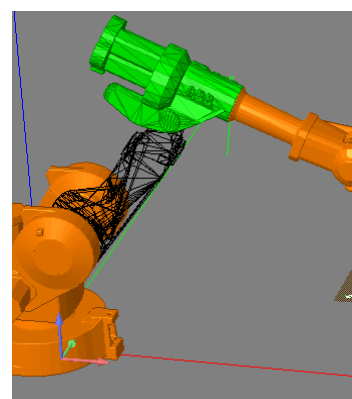
Hidden surface mode shows the geometry triangulation with filling color included

Polygon shows the geometies in shaded pologon mode

Toggles the geometry visibility

Toggles the geometry transparency

If no geometries are selected clicking visualization mode icons will change visualization mode for all geometries in the simulation project.

Capturing Pictures and Animations

Menu operation **View->Capture Picture..** will save the current view as a picture file. JPG and PNG file formats are supported.

Menu operatoin **View->Save AVI File..** will save an animation about the robot running the currently loaded path. Current screen size and view angle is used for the video.

First you will be prompted with file dialog for the name and location of the *.AVI file to be created.

Then, before the video is generated a video codec to be used is prompted.

After video codec is selected the system will take some time in generating the video. Eventually the video
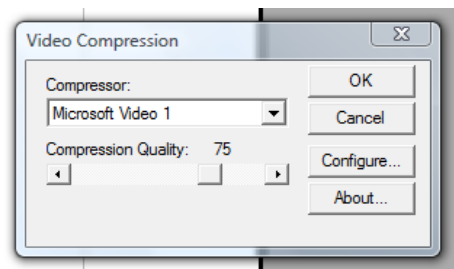
4. Managing Robot Cell Layout

Selecting Robot Model

The robot model to be used for new simulation projecs is selected in a configuration file named 'coniferrob.ini' that resides in the directory where Conifer Rob was installed.

The file contains entry named 'configuration', for example

```
configuration=ROBOT_IRB4400
```

The supported values for the 'configuration' entry are:

Value	Robot Model
ROBOT_IRB2400_15_20	ABB IRB 2400-20/1.5 (Experimental)
ROBOT_IRB4400	ABB IRB 4400-60/1.96
ROBOT_IRB6400_24_120	ABB IRB 6400-120/2.4
ROBOT_IRB6400_25_150	ABB IRB 6400R-150/2.5
ROBOT_IRB6400_28_150	ABB IRB 6400R-150/2.8
ROBOT_IRB6400_30_100	ABB IRB 6400R-100/3.0
ROBOT_IRB6600_175_255	ABB IRB 6600-175/2.55
ROBOT_KR125_PARAT	KUKA 125 PARAT
ROBOT_KR150L110-2	KUKA KR150L110
ROBOT_KR150L110-2_VK	KUKA KR150L110 (customized)
ROBOT_KR150_3	KUKA KR150-3
ROBOT_MOTOMAN_YR_NP50_M_A00	Motoman YR NP50 M-A00 (Experimental)

Changing selected robot for an existing robot simulation project is not supported.

Managing Tool Containers Library

Conifer Rob maintains a library of Tool Containers in each simulation project separately. Tool containers are geometric objects that are attached between the robot and the cutting tool. For example an electric engine that rotates the cutting tool is a tool container. Tooling containers can be nested i.e. electric engine can be attached to the robot via connector arm or an adapter. The chain of tool containers move the cutting tool in relation to the robot arm and thus must be taken into account when calculating the kinematic tool correction for the robot.

Creating New Tool Containers

New tool containers are added to the library by selecting from dropdown menu **View->Manage Tool Containers**. "Manage tool containers" dialog will appear listing current tool containers in the tool container library of the current project.
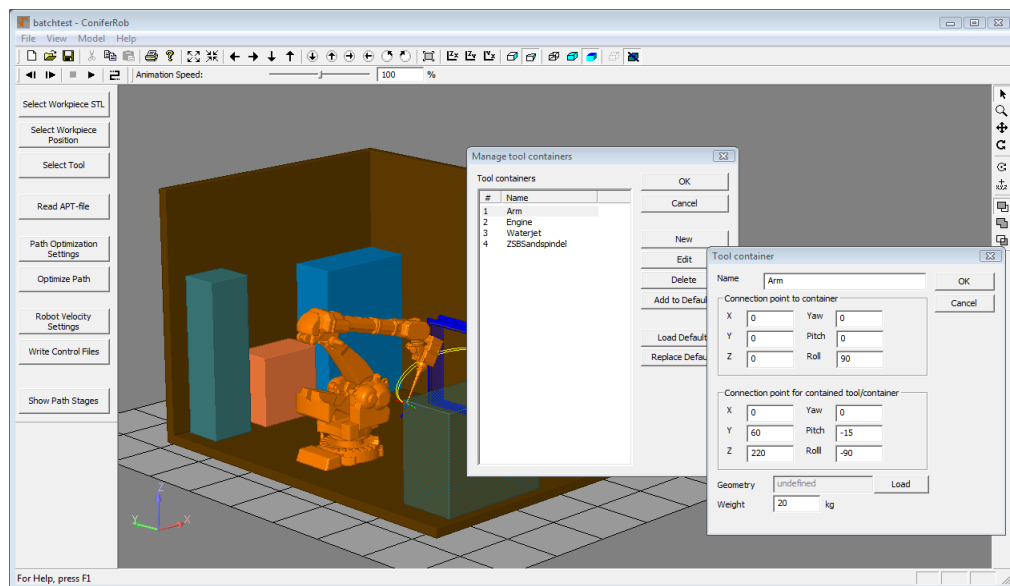
Clicking **New** button will open dialog from which the properties of new tool container are specified. Following properties must be given:

Name	User given name for the tool container
Connection point X to container	The X coordinate of the point from which the container connects to the tool container that contains this tool container (or robot if there is no containing tool container). The coordinate is specified in the coordinate system of the geometry of this tool container.
Connection point Y to container	The Y coordinate of the point from which the container connects to the tool container that contains this tool container (or robot if there is no containing tool container). The coordinate is specified in the coordinate system of the geometry of this tool container.
Connection point Z to container	The Z coordinate of the point from which the container connects to the tool container that contains this tool container (or robot if there is no containing tool container). The coordinate is specified in the coordinate system of the geometry of this tool container.
Yaw rotation of the connection point to container	The YAW rotation in the connection point to the containing tool container (or robot if there is no containing tool container). This effectively rotates the geometry of this tool container AND the contained tool containers and the tool.
Pitch rotation of the connection point to container	The PITCH rotation in the connection point to the containing tool container (or robot if there is no containing tool container). This effectively rotates the geometry of this tool container AND

	the contained tool containers and the tool.
Roll rotation of the connection point to container	The ROLL rotation in the connection point to the containing tool container (or robot if there is no containing tool container). This effectively rotates the geometry of this tool container AND the contained tool containers and the tool.
Connection point X contained tool/container	The X coordinate of the point to which the contained tool or tool container will be attached to. The coordinate is specified in the coordinate system of the geometry of this tool container.
Connection point Y to the contained tool/container	The Y coordinate of the point to which the contained tool or tool container will be attached to. The coordinate is specified in the coordinate system of the geometry of this tool container.
Connection point Z to the contained tool/container	The Z coordinate of the point to which the contained tool or tool container will be attached to. The coordinate is specified in the coordinate system of the geometry of this tool container.
Yaw rotation of the connection point to the contained tool/container	The YAW rotation of the contained items. This setting rotates the contained items around the connection point to contained items.
Pitch rotation of the connection point to the contained tool/container	The PITCH rotation of the contained items. This setting rotates the contained items around the connection point to contained items.
Roll rotation of the connection point to the contained tool/container	The ROLL rotation of the contained items. This setting rotates the contained items around the connection point to contained items.
Geometry	An STL geometry file defining the geometry for this coordinate system. Pressing the **LOAD** button will open a file dialog from which the file to be used can be selected.
Tool container weight	Weight of the tool container in kilograms [Kg]

Deleting Tool Containers

To delete a tool container from projects tool container library open "Manage tool containers" dialog by selecting from dropdown menu **View->Manage Tool Containers**. Select a tool container you wish to delete from the list and click **Delete** button.

Modifying Tool Containers

To modify a tool container in projects tool container library open "Manage tool containers" dialog by selecting from dropdown menu **View->Manage Tool**

Containers. Select a tool container you wish to delete from the list and click **Edit** button. A dialog similar to used when creating new tool containers will open from which the tool container properties can be modified.

<u>Setting Default Tool Containers</u>

System maintains a set of default tool containers which are initialized to the tool container library for new simulation projects. You can revert the simulation project to this default library by clicking **Load defaults** button in the "Manage tool containers" dialog.

Also, you can replace the default tool container library with the current one by clicking the **Save defaults** button.

The default tool container library is stored in the "ToolContainers" directory in the Conifer Rob installation directory (typically c:\program files\conifer rob). If you want to take a backup of the tool container library just backup this directory. To revert back to the backup replace the contents of the "ToolContainers" directory from your backup.

Managing Tools Library

<u>Creating New Tools</u>

Conifer Rob maintains a library of tools separately in each simulation project.

New tools are added to the library by selecting from dropdown menu **View->Manage Tools**. "Manage tools" dialog will appear listing current tools in the tool library of the current project.

Clicking **New** button will open dialog from which the properties of the new tool are specified. A tool can either be a simple one or a complex one. Simple tools are circle profiled tubes with optional rounding in the tool tip. Conifer Rob generates the geometry for simple tools automatically from the given parameters. For complex tools the tool geometry must be given as an STL file.

Following properties must be given to all tools:

Name	User given name for the tool
Hotspot offset	Hotspot offset from the tip of the tool geometry in the direction of the tool axis. Positive value moves the hotspot away from the tool. Negative value moves the hotspot inside the tool. Hotspot is the point which the robot considers as the tool location when running the robot program i.e. the hotspot is the point that will follow the defined path.
Weight	Tool weight in kilograms [Kg]

Following information must be given for simple tools:

Length	Tool length in millimeters (mm)
Corner radius	Tool tip rouding corner radius in millimeters (mm)

Diameter	Tool profile diameter in millimeters (mm)

Following information must be given to complex tools:

Profile geometry	An STL geometry file defining the geometry for this coordinate system. Pressing the **LOAD** button will open a file dialog from which the file to be used can be selected.
Connection point X to container	For complex tools: The X coordinate of the point from which the complex tool geometry connects to the tool container. The coordinate is specified in the coordinate system of the given geometry file.
Connection point Y to container	For complex tools: The Y coordinate of the point from which the complex tool geometry connects to the tool container. The coordinate is specified in the coordinate system of the given geometry file.
Connection point Z to container	For complex tools: The Z coordinate of the point from which the complex tool geometry connects to the tool container. The coordinate is specified in the coordinate system of the given geometry file.
Yaw rotation of the conneciton point to container	The X coordinate of the point to which the contained tool or tool container is attached to. The coordinate is specified in the coordinate system to the geometry of this tool container.
Pitch rotation of the conneciton point to container	The X coordinate of the point to which the contained tool or tool container is attached to. The coordinate is specified in the coordinate system to the geometry of this tool container.
Roll rotation of the conneciton point to container	The X coordinate of the point to which the contained tool or tool container is attached to. The coordinate is specified in the coordinate system to the geometry of this tool container.
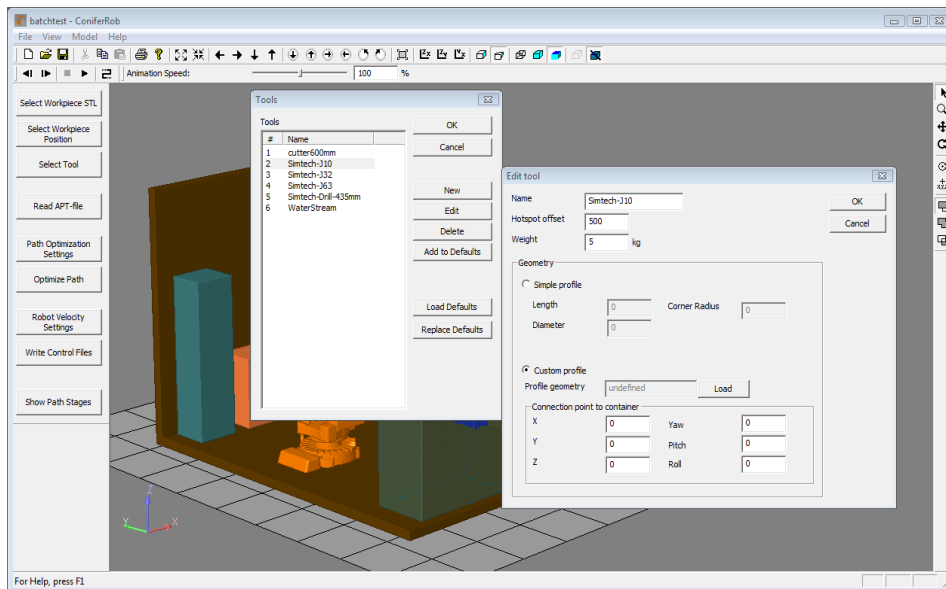
<u>Deleting Tools</u>

To delete a tool container from projects tool library open "Manage tools" dialog by selecting from dropdown menu **View->Manage Tools**. Select a tool you wish to delete from the list and click **Delete** button.

<u>Modifying Tools</u>

To modify a tool in projects tool library open "Manage tools" dialog by selecting from dropdown menu **View->Manage Tools**. Select a tool you wish to delete from the list and click **Edit** button. A dialog similar to used when creating new tools will open from which the tool properties can be modified.

<u>Setting Default Tools</u>

System maintains a set of default tools which are initialized to the tools library for new simulation projects. You can revert the simulation project to this default library by clicking **Load defaults** button in the "Manage tools" dialog.

Also, you can replace the default tool library with the current one by clicking the **Save defaults** button.
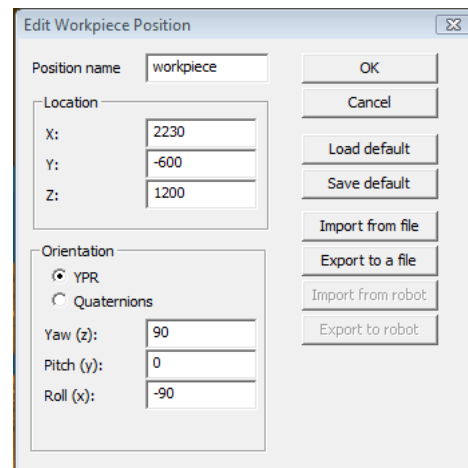
The default tool library is stored in the "Tools" directory in the Conifer Rob installation directory (typically c:\program files\conifer rob). If you want to take a backup of the tool library just backup this directory. To revert back to the backup replace the contents of the "Tools" directory from your backup.

Workpiece Positioning

This operation is available only after supervisor login. Also, before you can position the workpiece you have to define the workpiece geometry.

To move the workpiece in the system select from dropdown menu **Model->Workpiece Positioning..** or alternatively from the left toolbar **Select Workpiece Position.**

An 'Edit Workpiece Position' dialog will open. From this dialog you can set the workpiece location in the robot cell for this simulation project document. Location is given in global coordinate system. By clicking **Load Default** you can load the system default location for the workpiece position and by clicking **Save Default** you can store the workpiece location in the current simulation document as the system default. The system default is used for all new simulation project documents as default workpiece location.
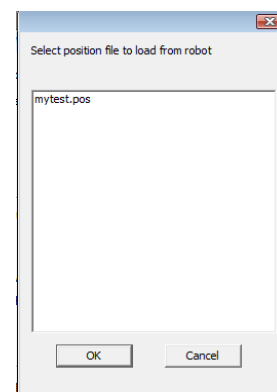
Workpiece location can also be imported from a file. The supported file format is a simple text file consisting of 6 or 7 decimal numbers separated by either space or tab character(s). If the file contains 6 numbers the position is assumed to be in YPR format (x,y,z,yaw,pitch,row) and if the file contains 7 numbers the format is assumed to be in quaternion format (x,y,z,q1,q2,q3,q4). The position export function always export the position in quaternion format.

Finally, the workpiece position can be uploaded to a robot with **Export to robot** and loaded from robot with **Import from robot**. In exporting the name of the *.pos file is asked and the position is then uploaded via FTP to the robot. In importing the Conifer Cast lists all the *.pos files in the position file directory in the robot and lists them. To download the position select the position file and click Ok. The FTP properties need to be configured for this, see Installation chapter for details.
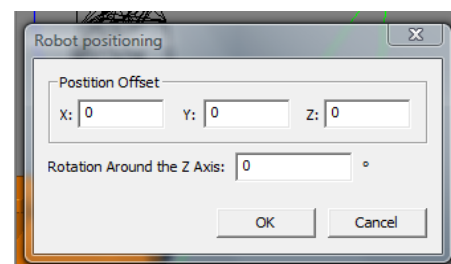
Robot Position

Changing Robot Position

This operation is available only after supervisor login.

To change the robot location and orientation the robot cell for this robot simulation project select from dropdown menu **Model->Robot Positioning..**

A 'Robot positioning' dialog will open from which you can change the robot location and orientation in the robot cell.

Default Robot Position

To modify the default robot location used for new robot simulation projects you have to create/modify a file named 'robot.pos' in the Conifer Rob installation directory.
This file as the following syntax:

```
X Y Z rotZ
```

..where the X, Y and Z define the default robot location in the robot cell and the rotZ defines the robot rotation around the Z axis in degrees.

Example:

```
100.0 0 0 45
```

Setting Robot Home Position

The robot home position for current simulation project is set in **Optimization Settings.** See chaper **Optimization Settings** for details on this.
The default position for robot home position is defined in file home.jnt which locates in the installation directory of the Conifer Rob. The format of the file is following:

<jount1> <joint2> <joint3> <joint4> <joint5> <joint6>

..where jointN gives the joint N rotation value for home position in degrees.

Example:

```
-0.000 -0.000 -0.000 0.000000 0.000000 0.000000
```

Managing Obstacles

Creating New Obstacles

This operation is available only after supervisor login.

You can import STL geometries as obstacles to your robot simulation project. These obstacles are visualized on the screen and used in the collision detection to determine wether the robot program is safe to run.
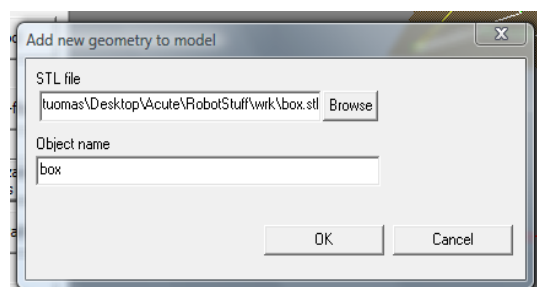
To import a new obstacle to the system select from dropdown menu **Model->Add STL...** and an 'Add new geometry to model' dialog will open. Clicking **Browse** will open a file dialog from which you can select an STL file defining the obstacle geometry to be imported in the simulation project. To **Object name** edit line give a human readable name for the obstacle. This name will be used for referring to the obstacle in the user interface.

After clicking **OK** from the 'Add new geometry to model' dialog an 'Object positioning dialog' will open. On the left side you see a list of obstacle geometries in the simulation project. The newly imported obstacle is automatically selected as default. On the right side there are entries for positioning and rotating the geometry in the robot cell. Making changes to these entries becomes visible on the screen immediately. After the obstacle geometry has been positioned to it's correct location in the robot cell click **OK**.
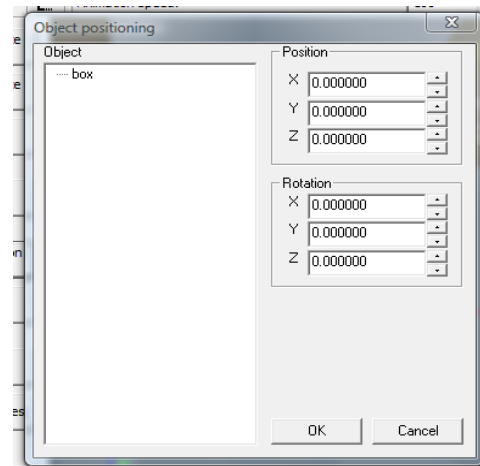
Deleting Obstacles

This operation is available only after supervisor login.

To remove an obstacle from the robot model select from dropdown menu **Model->Remove STL..**

A 'Remove object' dialog will open. The dialog shows the list of obstacles in the current simulation project. Select the obstacle you wish to remove and click **Remove** to remove the obstacle.
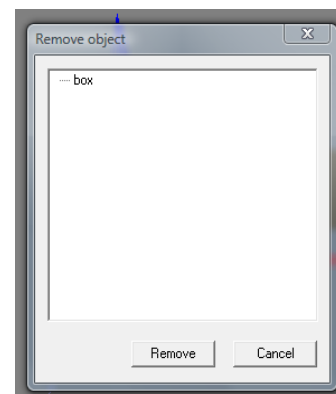
Moving Obstacles

This operation is available only after supervisor login.

To move obstacles in the robot cell select from dropdown menu **Model->Position STL...** An 'Object positioning dialog' will open from which the obstacles can be moved and rotated within the robot cell.

Setting Default Obstacles

The Conifer Rob will load all the STL files in the subdirectory named 'Obstacles' under installation directory as initial default obstacles for any new robot simulation document. You can modify the default obstacles by creating/deleting STL files from/to this directory. Obstacles from current robot simulation project can be exported to be used as default by selecting the obstacle geometry with mouse and using the **Export STLs** function found in the **File** menu. The exported STL file should then be copied under the 'Obstacles' subdirectory under Conifer Rob installation directory.

5. Path Setup

Selecting Workpiece Geometry

To set up the workpiece geometry for the simulation project either select **Select Workpiece STL**.. from the left hand toolbar. A 'Select Workpiece Model' dialog will open. From this dialog you can define box shaped standard workpiece geometry or load a complex workpiece geometry as an STL file. Complex workpiece can be of arbitary shape.

For standard workpiece geometries select either one of the given sizes (3000mm x 2200mm, 2500mm x 2000mm or 2000mm x 1600mm, 1400mm x 1200mm) or select the **Custom** choice and give the dimensions manually. Also give the workpiece geometry thickness in the **Mold Height** entry. For complex workpiece geometry clicking **Other** button will open a file dialog by which you can select an STL geometry file to be used as a workpiece geometry.
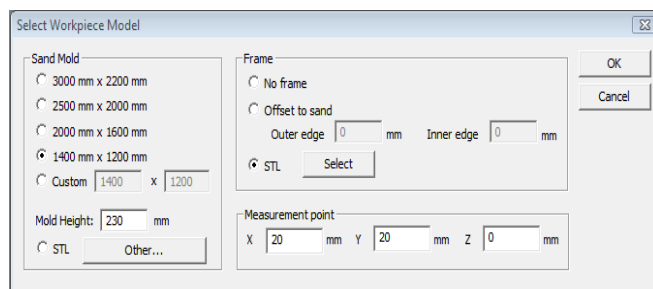
Frame is a solid geometry around the work piece that holds the workpiece together in correct place. Conifer Rob can generate a frame object around the work piece automatically using offsets. The offsets define the thickness of the frame in x and y directions around the frame (x & y axis in workpiece coordinate system). The min and max z edges of the frame are open i.e. There is no frame wall in those directions as the work on the workpiece is done from the max z direction when frames are used (again, workpiece coordinate system). In addition to automatically generated frames the frame can also be modeled in CAD system and imported in Conifer Rob in STL format using **Select** button.

Often, especially when frames are used, it is not feasible to measure workpiece position from the workpiece coordinate system origo which resides in the corner of the workpiece box. In such case, if realistic positioning of the workpiece and frame geometry are desired, a measurement point offsets can be given to move the workpiece coordinate system away from the workpiece box corner to a location where measurement is more practical.

Selecting Tool Containers

Tool containers are objects that are attached to the robot and to which the tool then be attached. Tool containers are managed in tool container library.

To select the tool containers to be used in simulation select from dropdown menu **Model -> Select Tool Containers**. A 'Tool Containers' dialog will open up. This dialog shows the list of the tool containers currently attached to the robot.

Attaching Tool Container To Robot
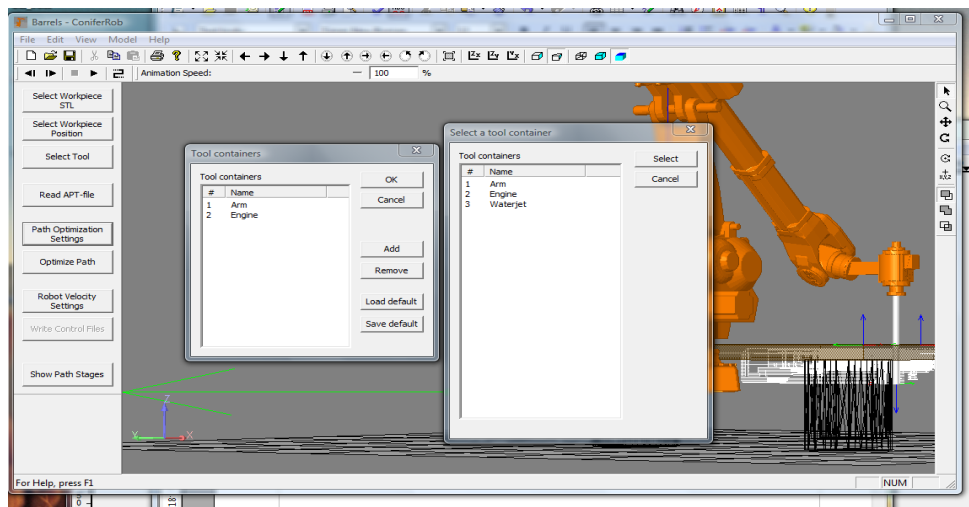
To attach a tool container to robot open 'Tool Containers' dialog by selecting dropdown menu **Model -> Select Tool Containers.** In this dialog click **Add** button. A 'Select Tool Container' dialog will appear. Select the tool container to add and click **Select.** Confirm the change by clicking **OK** in the 'Tool Containers' dialog.

Removing Tool Container From Robot

To remove a tool container from robot open 'Tool Containers' dialog by selecting dropdown menu **Model -> Select Tool Containers.** Select the tool container to remove from the robot and click **Remove.** Confirm the change by clicking **OK** in the 'Tool Containers' dialog.

Selecting Default Tool Containers

When new simulation project is created the default tool containers will be attached to the robot. To modify this default tool container selection modify the tool container selection in the current simulation project and then from the 'Tool Containers' dialog click **Save Default.** This will save the current tool container selection as default which will be used for all new simulation projects.

To revert back to default tool container selection click **Load Default** button in the 'Tool Containers' dialog.

Selecting Tool

Attaching Tool
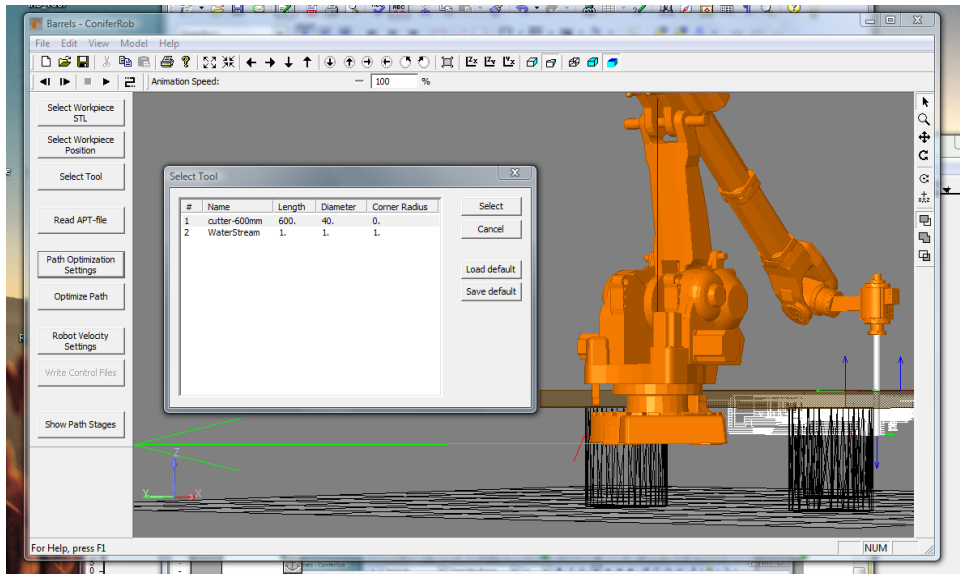
To select the current tool attached to the tool container (or in the absense of tool container - the robot itself) select dropdown menu **Model -> Select Tool**. A 'Select Tool' dialog will open. This dialog lists all the tools in the simulation projects tool library. Select the new tool to be used from the list and click **Select**.

Selecting Default Tool

When new simulation project is created the default tool will be attached to the tool container. To modify this default tool selection modify the tool selection in the current simulation project and then from the 'Select Tool' dialog click **Save Default.** This will save the current tool selection as default which will be used for all new simulation projects.

To revert back to default tool selection click **Load Default** button in the 'Select Tool' dialog.

Reading APT File

This operation requires that the workpiece geometry has been defined first.

In order to load an APT path to Conifer Rob select dropdown menu **Model -> Load APT File** or alternatively click **Read APT-file** button from the left hand toolbar.

A file dialog will open for selecting the APT file to be loaded. Select the APT file and click Ok. The APT file will not be loaded to the simulation project.

Conifer Rob will perform initial reachability analysis for the path defined in the APT file and renders the path to the screen so that reacable fragments of the path are rendered with white color while non-reacable framgments are rendered with red color. If some (or all) parts of the path are unreacable you can try to fix this by moving the path within workpiece using **Path Positioning..** function in the **Model** menu. If you have supervisor access you can also try to move the workpiece or the robot in the robot cell to make the path reachable.

Now that the path has been loaded it is possible to animate the robot running the path. Also it is possible to do modifications to the path via **Show Path Stages** operation found in the left hand toolbar.

Path Positioning

This operation is available only after APT file has been read in.

You can move the path positionining in the workpiece geometry by selecting **Model -> Path Positioning..**. A 'Path positioning' dialog will open from which the path position and Z rotation in the workpiece coordinate system can be changed. Give new path location and orientation and click OK. Conifer Rob will not recalculate the reacability for the path according to new path position.
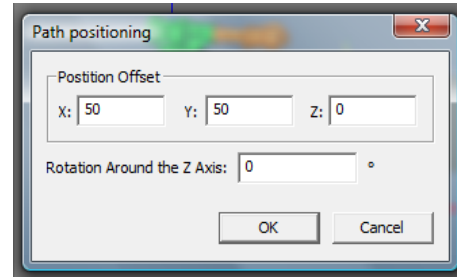
Robot Animation

Once the APT file has been read the Conifer Rob can animate the robot running the given path. Use Stages Toolbar in the top of the screen to run the animation. You can also use the **Show Path Stages** function found in the left hand toolbar to navigate the path in detail.

6. Path Optimization

In path optimization Conifer Rob will determine the approach (and exit) from the robot home position. Most importantly the optimization process will look for the best possible robot configuration for running the path in current robot cell setup and optimize the tool rotation around the tool symmetry axis. The loaded APT source defines only 5 degrees of freedom leaving the rotation around the tool axis open. The optimization will bind this extra degree of freedom and selects a rotation for each step so that robot joint movements are minimized and robot singularity points are avoided. Also – when collision avoidance feature is enabled – the optimization process will do collision analysis for the robot running the path and selects the tool axis rotation so that collision is avoided.

Path Optimization Settings

The set properties for optimization process select **Path Optimization Settings** from the left hand toolbar.

The values you can set here are:
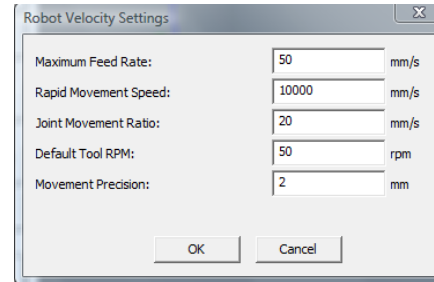
Name	Description
Path Z offset	Moves the path in Z direction
Maximum Path Length	Maximum path length in steps. Paths longer than this will be split in several path segments.
Max Approach Length	Maximum allowed apprach movement length.
Weight	Optimization criteria – tells how much the optimization emphasis the optimization gives for minimizing the robot joint angle changes and how much the optimization tries to keep the robot joint angles as close as possible to the home position.
Translation Resolution	Translation resolution used in approximating joint movements as a sequence of linear movements. Also used

	in linear motion check. Smaller value gives better optimization results but takes longer to optimize.
Rotation Resolution	Rotation resolution for linear motion check. Smaller value gives better optimization results but takes longer to optimize.
Rotation Limit	Min/Max values for the tool rotation. By default these are -180deg to +180deg meaning full circle is available for tool rotation. By changing these values it is possible to deny certain tool rotation sectors to be used in path optimization.
Singularity Limit	Limit angle in degrees. Defines how close to a singularity point robot is allowed to move.
Joint Margin	Safety limit for robot joint angle limits in degrees. Any joint in robot is not allowed to get any closer to its angle limit than this value.
Joint 5 Safety Margin	Safety limit for robot's 5th joint angle limit in degrees. The 5th joint in the robot is not allowed to get any closer to its angle liit than this value.
Configuration constraints	By deselecting some configurations here it is possible to force the optimization not to use certain robot configurations.
Collision detectionwhile optimizing path	When enabled the optimization process will do collision check for each path stage and selects only configurations and tool rotations in which collisions do not occur.
Robot home position	This entry defines the robot home position to be used. Home position is defined as joint angles in degrees. Also, robot joint angle limits can be configured here
Reduce speed at corners	If selected the optimization will monitor for robot tool acceleration speed at corners and if it exceeds the given trenshold acceleration it will run change the robot program so that the corner is run slowly enough so that the acceleration treshold is not exceeded.
Visit home between segments	If selected the animation will add visit to the robot home position between every robot program segment.
Load default home	This button will replace the currently set robot home position with the default.
Save default home	This button will store the currently set robot home position as the default.

Robot Velocity Settings

To set the robot velocity settings click **Robot Velocity Settings** button in the left hand side toolbar.

Following velocity settings can be set:

Name	Description
Maximum Feed Rate	Maximum feed rate. This is used as default if feed rate is not given in APT file.
Rapid Movement Speed	Movement speed for rapid movement commands.
Joint Movement Ratio	Relative joint velocity factor for joint movements.
Default Tool RPM	Default tool rotation speed. This is used if rotation speed is not specified in APT file.
Movement Precision	Tooling tolerance

Path Optimization
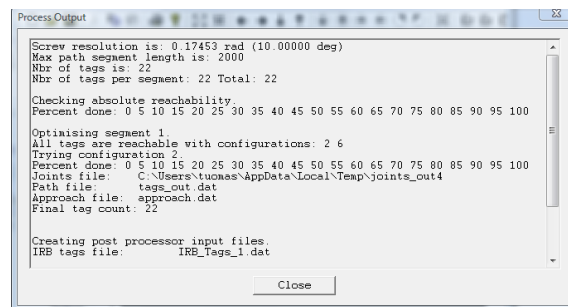
This function requries that the APT file has been loaded in.

Path optimization is started from the left hand side toolbar button **Optimize Path**.

A 'Progess Ouput' dialog will open to which the optimization process will write it's progress information.

The path optimization will try out the loaded path in all possible 8 robot configurations and tries determine the optimal tool rotation so that all stages are reacheable and robot joint rotation velocities are minimized and robot operates as close as possible to the home position joint angles.

Optimization process inserts the path an approach segment from the robot home position and exit segment from the path end point back to the robot home position. If path is very long the optimization process will split the path into several segments so that each segment can be loaded separately to the robots limited memory so that larger paths can be run in separate fragments with robots having limited controller memory.

Manual Path Manipulation

<u>Viewing Path Stages</u>

This function requires that APT has been loaded to the project.

Selecting **View Path Stages** from the left hand side toolbar will open stages dialog which shows the currently active path as a list of command steps. The currently active step is shown in the dialog as selected and during animation this selection will move forward as the program is run forward. Also, clicking a stage in the stages list will bring the robot to that location in the program.

The list can shows the path stages in two modes. First mode (**Show Tool Position in Workpiece CS**) shows the tool location and orientation in path coordinate system.

The second mode (**Show Tool Position in Robot CS**) shows the tool location and orientation in the robot coordinate system.

The third mode (**Show Joint Angles (Abb Style)**) shows the location as robot joint angles in ABB style. In this form the 3rd joint angle is given relative to vertical plane instead of 2nd joint.

The fouth mode (**Show Joint Angles (deg)**) shows the location as robot joint angles.

For each step the program feed rate (Speed) and Tool rotation speed (RPM) is shown. Column APT tells wether the stage is part of the work path or a movement command added by the Conifer Rob path optimization process.

<u>Creating New Path Stages</u>

In 'Robot path stages' dialog it is possible to modify stages in the path.

To add a new point in path select the position to which you want to add the new stage in the path and click **Add** in the robot path stages dialog. An 'Edit Path Stage' dialog will open with the fields pre-filled with the values of the stage you selected. This dialog allows modifying the tool position in either path coordinate system or robot coordinate system. For tool orientation both YPR and quaternion system are supported. Modify the values here and click **OK** to add a new stage before the stage you selected. To test the location first click **Apply**. This will store the new path stage to the path and move the robot to this new location so that you can preview on the screen the change was correct and keep the dialog open for the new stage so that you can make corrections.

The properties for new stage are:
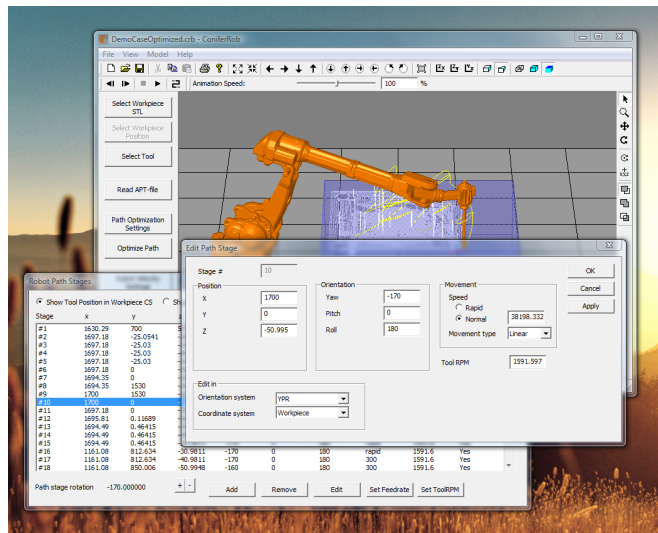
Name	Description
Position X	Tool location for the stage in selected coordinate system
Position Y	Tool location for the stage in selected coordinate system
Position Z	Tool location for the stage in selected coordinate system
Orientation Yaw	Tool orientation for the stage (deg)
Orientation Pitch	Tool orientation for the stage (deg)
Orientation Roll	Tool orientation for the stage (deg)
Orientation Q1	Tool orientation for the stage (quaternions)
Orientation Q2	Tool orientation for the stage (quaternions)
Orientation Q3	Tool orientation for the stage (quaternions)
Orientation Q4	Tool orientation for the stage (quaternions)
Movement Speed Rapid	Movement to the stage location is to be done as rapid movement
Movement Speed Normal	Movement to the stage location is to be done with given speed
Movement Type	Linear movement means tool will move to the new stage location along straight linear path from the previous stage. Joint movement will rotate all joints at nearly-linear rotation speed to reach the new location. In the joint movement type the path of the tool can become

	quite complex and this mode is usually used only in approaching the work path from the robot home position and in the exit stage from the path to the home position.
Tool RPM	Tool rotation speed for the stage

<u>Deleting Path Stages</u>

To remove a path stage select the stage (or several stages – this can be done either by dragging the mouse on the list or keepign the SHIFT key down while clicking on the list) from the list and click **Remove** button.

<u>Modifying Path Stages</u>

Moving Stage

To move a stage location click the stage you want to modify on the list and then click **Edit.** 'Edit Path Stage' dialog will open. Change the path location from the dialog and click OK.

Rotating Stage

To manually change the tool rotation for a path stage select the path stage (or several stages) from the stages list and click the **+/-** (plus/minus) buttons on the dialog. The path stages YAW rotation (rotation around the tool axis) will change and the robot on the screen will be adjusted to the new rotation. Note that

Changing Stage Properties

As when creating a new path stage to the path the 'Edit Path Stage' can also be used for modifying other path stage properties such as the movement speed, movement type and tool rotation RPM .

7. Collision Detection and Avoidance

Collision Detection

This option is only available after APT file has been read in.

To do collision detection for the current path select from dropdown menu **Model -> Check for Collisions..**

The Conifer Rob will now simulate running the robot program in memory and checks each path step for collision. If collisions are found the colliding parts in the part are rendered with red color and the robot is driven to the location where the first collision occurred.

The collisions are checked between all the robot and tool container parts and the work piece and obstacles. The collisions of the tool geometry are checked against the obstacles but not the workpiece.

IMPORTANT: Currently, the collision detection does NOT check the approach (from the home position) and the exit (to the home position).

Collision Avoidance

During path optimization if the **Collision Detection while Optimizing** option is selected from the **Path Optimization Settings** the system will do collision avoidance during path optimization.

The optimizatio process checks each path step for collision and accepts only the configurations and tool rotations in which it does not find collisions.
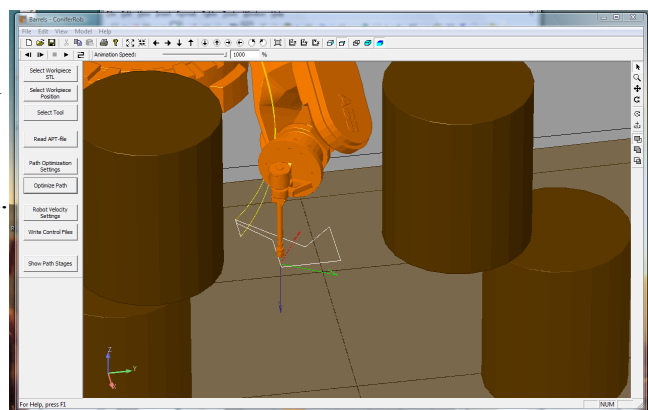
8. Exporting Results

Exporting APT

This function requires that an APT file has been loaded to the simulation project.

To export the path as APT file select from dropdown menu **File->Export APT..**

A file dialog will open asking the file name for the new APT file to be exported.

The exported file will contain the path and possible modifications made to it in the Conifer Rob. The exported APT is presented in the workpiece coordinate system i.e. path position translation is applied to the path points before export. Thus it is possible to import and APT path to Conifer Rob, move and rotate it, modify individual path points in it and then export the modified path back to APT file for further use. However, because APT format defines only 5 degrees of freedom the exported APT does **not** contain the tool rotation optimization created by Conifer Rob.

Generating Robot Program

This option is available only after path optimization has been done.

To export the optimized path as a robot program select 'Write Control Files' from the left hand toolbar. A file dialog will appear asking for a file name for the robot program to be generaetd. Give a file name for the robot program and click **Ok.**

Now the Conifer Rob will generate a robot program which can be loaded in to a real robot for running.

Uploading Robot Program to Robot

If the workstation on which the Conifer Rob is running has a working TCP/IP connection to the robot, if FTP properties have been defined in Conifer Rob installation and if the robot supports FTP access, you can after generating the robot program upload it automatically to the robot. To do this, select **Upload program to robot** from the **File** menu.

Conifer Rob will open an FTP connection to the robot and upload the last generated robot programs to robot in directory specified by **robotftpprogramdirectory** entry in coniferrob.ini (see Installation chapter for details).

9. Batch Runs

Using batch files allows optimizing and generating robot programs from several APT paths in one run. The task is defined in a batch file that should have a postfix .crbbat in its file name. The .crbbat file consists of lines, each defining one *.apt file to process.

The line structure of the .crbbat file is

handleapt <mname> <aptfilename> <wpfilename> <pposfilename>

..where <mname> is the module name, <aptfilename> is the file name of the *.apt file defining the path to be processed, <wpfilename> is the file name of the *.pos file defining workpiece position and <pposfilename> is the file name of the *.pos file defining the path positioning of the path wihin workpiece.

The batch function is started from selecting **Run batch** from **File** menu. A file dialog will open asking for you to provide the .crfbbat file that defines the batch to run.

When you do this you should have a simulation document open that defines the Robot cell and optimization parameters for the batch. Once batch file is selected the current document is saved automatically and for each handleapt command the system will create a new simulation document (*.crb), load the apt file given in the .crbbat file line to the simulation d9ocument, set workpiece position and path position as defined in the .crfbbat line, run optimization with the current optimization settings and generates robot program to the directory where .crfbbat file resides.

If main program template is defined as **Templates\mainprogram.template** in the directory where Conifer Rob executable resides (typically this is "c:\program files\conifer rob" or c:\program files (x86)\conifer rob") the batch operation will also generate a main file according to the definitions in the template file.

If the batch operation runs successfully the **File->Upload program to robot** operation can be used to upload the generated modules and main program directly to the robot via FTP.

APPENDIX A: Robot Program Templates

How robot program generation works?

Conifer Rob uses templates for generating robot program from the optimized work path in the memory. The data in the template file is copied to the robot program as is. However – specially formated items in the template file – so called 'tags' are given special treatment. The tags are used for iterating data in optimized path and expanding data from the path to the robot program. The data in the oprimized path can be accessed via variables. The template expansion procedure can also modify the values of variables and thus maintain an internal state during the template expansion.

Templates

The used templates are defined in the coniferrob.ini configuration file that resides in the Conifer Rob installation directory (which is typically the c:\program files\conifer rob). The template information is stored in the configuration file entry 'template'. The value of the entry has a following structure:

template=<postfix1>;<templatefile1>[;<postfix2>;<templatefile2>[..]]

...where the <postfixN> is the default file name postfix for the file generated with template and the <templatefileN> is the template file used for generating the file. If several template files are given the they are each run separately with the same path data and will generate a separate result file. This can be used to generate robot program that consist of several files - such as the KUKA robot programs with the program consisting of both *.dat and *.src files.

Example:

```
template=.dat;Templates/template-kuka-vkrc-2-
dat.txt;Templates/template-kuka-vkrc-2-src.txt
```

..will configure the system to run two template files – first generating a *.dat file and the second generating an *.src file.

The template files are stored in the Conifer Rob installation directory subdirectory 'Templates'.

Variables

Variables are organized in scopes which can contain other scopes. The main level scope is called GLOBAL scope. The variables provide access to data that is expanded

to robot program as specified by robot program template. In addition to predefined variables a template can also define an manipulate variables of its own.

<u>GLOBAL scope</u>

Variables for main program

Name	Description
NAME	Main program filename base (generated from the simulation project file (*.crb) name

Sub-scopesfor main program

Name	Description
MODULE	Modules generated in this run

Variables for robot program modules

Name	Description
LFTOOLX	Tool correction in X
LFTOOLY	Tool correction in Y
LFTOOLZ	Tool correction in Z
LFTOOLQ1	Tool correction rotation in quaternions
LFTOOLQ2	Tool correction rotation in quaternions
LFTOOLQ3	Tool correction rotation in quaternions
LFTOOLQ4	Tool correction rotation in quaternions
LFTOOLR1	Tool correction rotation in YPR angles (degrees)
LFTOOLR2	Tool correction rotation in YPR angles (degrees)
LFTOOLR3	Tool correction rotation in YPR angles (degrees)
LFW1	Workpiece location X relative to robot coordinate system
LFW2	Workpiece location Y relative to robot coordinate system
LFW3	Workpiece location Z relative to robot coordinate system
LFWR1	Workpiece rotation in quaternions
LFWR2	Workpiece rotation in quaternions
LFWR3	Workpiece rotation in quaternions
LFWR4	Workpiece rotation in quaternions
LFWRYPR1	Workpiece rotation in YPR angles (degrees)

LFWRYPR2	Workpiece rotation in YPR angles (degrees)
LFWRYPR3	Workpiece rotation in YPR angles (degrees)
FEEDRATE	Maximum feed rate given in robot velocity settings
RAPIDSPEED	Speed for rapid movement operations, given in robot velocity settings
TOLERANCE	Tooling tolerance
AXISVELOCITY	Maximum allowed axis velocity for the robot
OUTBASE	File name of the generated robot program file with the running number ohmitted
TOOLNAME	Name of the currently selected tool
SPINDLERPM	Default spindle rotaton speed, given in robot velocity settings
FILEEXTENSION	Filename postfix for the generated file. Robot program template can modify this.
WORKPIECENAME	Name of the workpiece.
ROTATIONVEL	Obsolete, included for backward compatibility
ILINES	Count of commands in paths
IJOINTS	Count of joints in the robot
TOOLNR	Selected tool index in the tool library
MODULENAME	Suggested name for the program module. This is generated from workpiece positioning name and the APT file name.
WORKPIECEPOSITIONNAME	Name of the workpiece positioning. This is given in workpiece setup dialog.
TOOLWEIGHT	Combined weight of the tool and tool contaienrs in kilograms (given in the tool library)

Sub-scopes for robot program modules

Name	Description
JOINTS	Contains the robot home position as joint angles.
PATH	Paths in this robot program. If the APT program is large the optimization may split the program into several paths depending on path size limits given in optimization parameters.

MODULE scope

Variables

Name	Description
NAME	Name of the program module
HASTOOLNAME	0=tool name was not defined, 1=module has tool name defined
TOOLNAME	Tool name to use in program module

Sub-scopes

None

JOINTS scope

Variables

Name	Description
LF_JOINT1	Joint angle of the robot home position for the 1st joint
LF_JOINT2	Joint angle of the robot home position for the 2nd joint
LF_JOINT3	Joint angle of the robot home position for the 3rd joint
LF_JOINT4	Joint angle of the robot home position for the 4th joint
LF_JOINT5	Joint angle of the robot home position for the 5th joint
LF_JOINT6	Joint angle of the robot home position for the 6th joint

Sub-scopes

None

PATH scope

Variables

None

Sub-scopes

Name	Description
COMMAND	Robot commands forming the containing path

COMMAND scope

Variables

None

Sub-scopes

Name	Description
MOVEL	Linear movement command(s)

MOVEL scope

Variables

Name	Description
LFP1	Tool target x coordinate in workpiece coordinate system
LFP2	Tool target y coordinate in workpiece coordinate system
LFP3	Tool target z coordinate in workpiece coordinate system
LFQ1	Tool target orientation in quaternions
LFQ2	Tool target orientation in quaternions
LFQ3	Tool target orientation in quaternions
LFQ4	Tool target orientation in quaternions
LFR1	Tool target orientation in YPR angles (deg)
LFR2	Tool target orientation in YPR angles (deg)
LFR3	Tool target orientation in YPR angles (deg)
IC1	Angle sector flag 1
IC2	Angle sector flag 2
IC3	Angle sector flag 3
ISRAPID	1 is command is rapid movement, otherwise 0
FEEDRATE	Feed rate for movement
SPINDLERPMCHANGED	1 if spinlde RPM has changed since last movement command
SPINDLERPM	Spindle RPM for this movement

Sub-scopes

None

Template Language Specification

Static text

All text not enclosed in ${ .. } is considered as static text and will be expanded to the robot program as it is.

However, if the static text to be expanded contains ${ it must be presented as ${}

Example:

```
Oli hyva marjavuosi ja siksi saatiiin paljon mustikoita $
{}} foo $$ $$$ ..testidataksi
```

..will expand to...

```
Oli hyva marjavuosi ja siksi saatiiin paljon mustikoita $
{} foo $$ $$$ ..testidataksi
```

Variable expansion

Variables in global scope are expanded with following syntax:

${variablename}

..where the variablename is the variable name.

Variables in an iterated subscope (see FOREACH statement) are expanded with following syntax:

${scopealias.variablename}

..where the scopealias is the scopealias given in containing FOREACH statement and the variablename is the name of the variable in the interated scope instance.

${FOREACH <subscopename> <scopealias>} ... ${ENDFOREACH <scopealias>}

Foreach statement iterates over all found subscope instances of current scope having given scope name <subscopename>. Within the FOREACH, ENDFOREACH pair the variable values in the subscope can be referred with scope prefix <scopealias>.

The iteration count will be stored in scope variable INDEX as numeric value starting from 0.

Example:

```
${FOREACH PATH P}
    ${FOREACH COMMAND C}
        ${FOREACH MOVEL M}
            ${P.INDEX}
            ${M.LFP1}
        ${ENDFOREACH M}
    ${ENDFOREACH C}
${ENDFOREACH P}
```

..will iterate through all PATH subscopes at global scope and for each scope found there it will iterate over all contained COMMAND subscopes and for each such scope found it will iterate over all MOVEL subscopes found. For all found MOVEL subscopes a running number of the containing PATH and the value LFP1 variable in the MOVEL scope will be expanded.

${SET <variablename> = <expression }

Set statements stores the value of given expression <expression> in a global variable <variable>.

Example:

```
${SET lastSpindleValue = 0}
```

..will set the variable 'lastSpindleValue' in the global scope to numerical value zero.

The set value can then be expanded as...

```
${lastSpindleValue}
```

...or referred in expression as...

```
${IF lastSpindleValue=0}
...
${ENDIF}
```

${IF <variablename> <eqop> <expression> } ${ENDIF}

IF, ENDIF pair will expand the data between the IF and ENDIF if the expression <expression> expands to a value that matches with value of 'variablename' as specified by comparison operation <eqop>.
<eqop> can either be '=' meaning equal value or '!=' meaning non-equal value.

Example:

```
${IF lastSpindleValue=0}
     StartSpindle;
${ENDIF}
${IF lastSpindleValue!=0}
     StopSpindle;
${ENDIF}
```

.. will expand text 'StartSpindle;' to the robot program if global variable 'lastSpindleValue' has zero value. Otherwise text 'StopSpindle' will be expanded.

${DUMP}

Will expand the contents of all variables to the robot program. This is intended for debugging robot program templates.

Constant text as expression

Textual constant data in expression is presented in quotes (")

Example:

```
${IF questionanswer = "Yes"} Affirmative ${ENDIF}
```

..will expand 'Affirmative' to the robot program if the variable 'questionanswer' has textual value 'Yes'

Constant numeric value as expression

Numeric constant values in expression are presented as they are

Example:

```
${IF questionanswer = 0} Zero was given ${ENDIF}
```

..will expand 'Zero was given' to the robot program if the variable 'questionanswer' has numeric value 0.

Variable value as expression

Textual word in expression that is not enclosed in quotes and does not match on any expression operations described below is considered as a variable value expansion and the value of the variable will be used then.

Example:

```
${IF questionanswer = correctanswer} Correct! {ENDIF}
```

..will expand 'Correct!' if the variables 'questionanswer' and 'correctanswer' have the same value.

DIV

Expression operation DIV calculates the numeric value of the first operand divided with the numeric value of second operand. Operands are given in ()'s and separated with comma.

Example

```
${SET myvariable = 10 }
${SET divisor = 2 }
${SET myvariable = DIV(inputvalue, divisor) }
${myvariable}
```

..will calculate the 10 / 2 and store the value to variable 'myvariable' and then finally expand that value to the robot program.

MUL

Expression operation MUL calculates the product of the first and second operand. Operands are given in ()'s and separated with comma.

Example

```
${SET var1 = 3 }
${SET var2 = 4 }
${SET myvariable = MUL(var1, var2) }
${myvariable}
```

..will calculate the 3 * 4 (i.e. 12) and store the value to variable 'myvariable' and then finally expand that value to the robot program.

SUM

Expression operation SUM calculates the sum of the first and second operand. Operands are given in ()'s and separated with comma.

Example

```
${SET var1 = 3 }
${SET var2 = 4 }
${SET myvariable = SUM(var1, var2) }
${myvariable}
```

..will calculate the 3 + 4 (i.e. 7) and store the value to variable 'myvariable' and then finally expand that value to the robot program.

SUB

Expression operation SUB calculates subtracts the value of the second operand from the first operand. Operands are given in ()'s and separated with comma.

Example

```
${SET var1 = 3 }
${SET var2 = 4 }
${SET myvariable = SUB(var1, var2) }
${myvariable}
```

..will calculate the 3 * 4 (i.e. -1) and store the value to variable 'myvariable' and then finally expand that value to the robot program.

ASK <variablename> "Free question text here"

ASK statement prompts the end user with a question dialog and stores the answer the user gives to the variable <variablename>

Example:

```
ASK query "What is  the default tool RPM to be used?"
${query}
```

...will prompt the user with question "What is the default tool RPM to be used" and then expands the value user gives to the robot program